WHAT IS CLAIMED IS:

1. A variable gain amplifier device controlled by a first gain control signal, comprising:

a gain controlled amplifier having a gain and including a differential pair of first and second MOS type transistors configured to operate in a weak inversion region; and

a control signal converter configured to convert the first gain control signal into a second gain control signal, and supply the second gain control signal to the gain controlled amplifier to exponentially vary the gain with respect to the first gain control signal.

2. A variable gain amplifier device according to claim 1, wherein the differential pair of MOS type transistors of the gain controlled amplifier include a common source terminal configured to receive an input signal current and respective gates between which the second gain control signal is supplied, the gain controlled amplifier being configured to output an amplified output signal current from a drain terminal of the first MOS type transistor.

3. The variable gain amplifier device according to claim 1, wherein the control signal converter comprises a differential pair of third and fourth MOS type transistors including a common source terminal to which a direct current Io is supplied and configured to

operate in the weak inversion region, the third MOS type transistor including a drain terminal and a gate terminal which are connected to each other, a current $Io \cdot exp(-b \cdot Vc/V_T)$ (where, Vc is the first gain control signal, V_T is the thermal voltage, and b>0) being applied to the drain terminal of the third MOS type transistor, the fourth MOS type transistor including a gate terminal fixed to a constant direct current level, and a potential difference between the gate terminal of the third MOS type transistor and the gate terminal of the fourth MOS type transistor corresponding to the second gain control signal.

4. The variable gain amplifier device according to claim 3, wherein the control signal converter further comprises:

fifth and sixth MOS type transistors configured to operate in the weak inversion region, each of the fifth and sixth MOS type transistors including a source terminal connected to a fixed potential point and a gate terminal, and the sixth MOS type transistors including a drain terminal connected to the common source terminal of the third and fourth MOS type transistors,

a current mirror circuit including an input terminal connected to the drain terminal of the fifth MOS type transistor to receive an input signal current and an output terminal connected to the drain terminal

of the third MOS type transistor to output an output signal current,

a current source connected to a gate terminal of the fifth MOS type transistor and configured to generate a current proportional to the first gain control signal,

a constant bias voltage source connected between the gate terminal and the source terminal of the sixth MOS type transistor and the current source, and

a resistor connected between the gate terminal of the sixth MOS type transistor and the current source.

5. The variable gain amplifier device according to claim 4, wherein a ratio of the input signal current to the output signal current of the current mirror circuit is less than 1.

6. The variable gain amplifier device according to claim 4, wherein a ratio of the input signal current to the output signal current of the current mirror circuit exceeds 1.

7. The variable gain amplifier device according to claim 1, wherein the control signal converter has a transmission characteristic defined by:

$$Vy = V_T \cdot \ln\{\exp(b \cdot Vc/V_T) - 1\}$$

where, Vc is the first gain control signal, Vy is the second gain control signal, V_T is the thermal voltage, and $b>0$.

8. The variable gain amplifier device according

to claim 1, wherein said gain controlled amplifier has a input-output characteristics defined by:

$$Iout/Iin = 1/(1+\exp(Vy/(n\cdot/V_T))$$

where, Iin is the input signal current, Iout is the output signal current, Vy is the second gain control signal, V_T is the thermal voltage, and n is a constant.

9. A variable gain amplifier device controlled by a first gain control signal, comprising:

a gain controlled amplifier having a gain and including a first differential pair of first and second MOS type transistors configured to operate in a weak inversion region, and a second differential pair of seventh and eighth MOS type transistors configured to operate in a weak inversion region; and

a control signal converter configured to convert the first gain control signal into a second gain control signal, and supply the second gain control signal to the gain controlled amplifier to exponentially vary the gain with respect to the first gain control signal.

10. A variable gain amplifier device according to claim 9, wherein the first and second MOS type transistors include a common source terminal configured to receive a first input signal current and respective gates between which the second gain control signal is supplied, the seventh and eighth MOS type transistors include a common source terminal configured to receive

a second input signal current in a complementary relation to the first input signal current and respective gates between which the second gain control signal is supplied, the gain controlled amplifier being configured to output an amplified first output signal current from a drain terminal of the first MOS type transistor, and an amplified second output signal current in a complementary relation to the first output signal current from a drain terminal of the seventh MOS type transistor.

11. The variable gain amplifier device according to claim 9, wherein the control signal converter comprises a differential pair of third and fourth MOS type transistors including a common source terminal to which a direct current Io is supplied and configured to operate in the weak inversion region, the third MOS type transistor including a drain terminal and a gate terminal which are connected to each other, a current $Io \cdot \exp(-b \cdot Vc/V_T)$ (where, Vc is the first gain control signal, V_T is the thermal voltage, and $b>0$) being applied to the drain terminal of the third MOS type transistor, the fourth MOS type transistor including a gate terminal fixed to a constant direct current level, and a potential difference between the gate terminal of the third MOS type transistor and the gate terminal of the fourth MOS type transistor corresponding to the second gain control signal.

12. The variable gain amplifier device according to claim 11, wherein the control signal converter further comprises:

fifth and sixth MOS type transistors configured to operate in the weak inversion region, each of the fifth and sixth MOS type transistors including a source terminal connected to a fixed potential point and a gate terminal, and the sixth MOS type transistors including a drain terminal connected to the common source terminal of the third and fourth MOS type transistors,

a current mirror circuit including an input terminal connected to the drain terminal of the fifth MOS type transistor to receive an input signal current and an output terminal connected to the drain terminal of the third MOS type transistor to output an output signal current,

a current source connected to a gate terminal of the fifth MOS type transistor and configured to generate a current proportional to the first gain control signal,

a constant bias voltage source connected between the gate terminal and the source terminal of the sixth MOS type transistor and the current source, and

a resistor connected between the gate terminal of the sixth MOS type transistor and the current source.

13. The variable gain amplifier device according

to claim 12, wherein a ratio of the input signal current to the output signal current of the current mirror circuit is less than 1.

14. The variable gain amplifier device according to claim 12, wherein a ratio of the input signal current to the output signal current of the current mirror circuit exceeds 1.

15. The variable gain amplifier device according to claim 9, wherein the control signal converter has a transmission characteristic defined by:

$$Vy = V_T \cdot \ln\{\exp(b \cdot Vc/V_T) - 1\}$$

where, Vc is the first gain control signal, Vy is the second gain control signal, V_T is the thermal voltage, and b>0.

16. A wireless communication apparatus comprising:

a baseband signal generator configured to generate first and second transmission baseband signals orthogonal to each other;

first and second baseband signal amplifiers each including the variable gain amplifier device according to claim 1, and configured to amplify the first and second transmission baseband signals, respectively;

a quadrature modulator configured to multiply the amplified first transmission baseband signal by a first local signal to produce a first radio frequency signal, multiply the amplified second transmission baseband signal by a second local signal having a $\pi/2$-phase

differs from the first local signal to produce a second radio frequency signal, and combine the first radio frequency signal and the second radio frequency signal into a transmission radio frequency signal; and

a transmitter configured to transmit the transmission radio frequency signal.

17. The wireless communication apparatus according to claim 16, wherein the first and second baseband signal amplifiers further comprise cascode transistors, respectively, and the cascode transistors are arranged to transmit an output signal current corresponding to the first and second baseband signals from the variable gain amplifier device to the quadrature modulator.

18. A wireless communication apparatus comprising:

receivers configured to receive a radio frequency signal;

a quadrature modulator configured to multiply the received radio frequency signal by a third local signal to produce a reception first baseband signal, and multiply the received radio frequency signals by a fourth local signal having a $\pi/2$-phase different from the third local signal to produce a reception second baseband signal having a $\pi/2$-phase different from the first baseband signal;

first and second baseband amplifiers each including the variable gain amplifier device according to claim 1, and configured to amplify the first and

second reception baseband signals, respectively; and

a baseband signal processor configured to process the amplified first and second reception baseband signals.

19. A wireless communication apparatus comprising:

a baseband signal generator configured to generate first and second transmission baseband signals orthogonal to each other;

first and second baseband signal amplifiers each including the variable gain amplifier device according to claim 9, and configured to amplify the first and second transmission baseband signals, respectively;

a quadrature modulator configured to multiply the amplified first transmission baseband signal by a first local signal to produce a first radio frequency signal, multiply the amplified second transmission baseband signal by a second local signal having a $\pi/2$-phase differs from the first local signal to produce a second radio frequency signal, and combine the first radio frequency signal and the second radio frequency signal into a transmission radio frequency signal; and

a transmitter configured to transmit the transmission radio frequency signal.

20. The wireless communication apparatus according to claim 19, wherein the first and second baseband signal amplifiers further comprise cascode transistors, respectively, and the cascode transistors are arranged

to transmit an output signal current corresponding to the first and second baseband signals from the variable gain amplifier device to the quadrature modulator.

21. A wireless communication apparatus comprising:

receivers configured to receive a radio frequency signal;

a quadrature modulator configured to multiply the received radio frequency signal by a third local signal to produce a reception first baseband signal, and multiply the received radio frequency signals by a fourth local signal having a $\pi/2$-phase different from the third local signal to produce a reception second baseband signal having a $\pi/2$-phase different from the first baseband signal;

first and second baseband amplifiers each including the variable gain amplifier device according to claim 9, and configured to amplify the first and second reception baseband signals, respectively; and

a baseband signal processor configured to process the amplified first and second reception baseband signals.